

Getting Started with R

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Introduction

- This guide shows how to:
 - Download and install R and RStudio
 - Understand how base R differs from RStudio
 - Navigate the RStudio environment (the 4 panes)
 - Format flat files (like CSV) for loading
 - Load a dataset (flat file and pointers to other resources)
 - Install and load libraries
 - Create objects
 - Conduct basic analyses
 - Save datasets
 - Save R Markdown and Quarto files

1 Download and Install R and RStudio

- R is the programming language. RStudio (by Posit) is a popular Integrated Development Environment (IDE) for R.
- Install R first, then RStudio.

Steps

- 1) Download R (CRAN):
 - <https://cran.r-project.org/>
 - Click “Download R for Windows” or “macOS” or “Linux”
 - Choose the latest release, then run the installer
- 2) Download RStudio Desktop (free):
 - <https://posit.co/download/rstudio-desktop/>
 - Download the installer for your OS and run it
 - Open RStudio after installing (R should already be installed)

Check versions

```
R.version.string
```

```
[1] "R version 4.4.3 (2025-02-28)"

# If running inside RStudio, this may show RStudio version:
if (exists("RStudio.Version")) {
  try({
    v <- RStudio.Version()
    paste("RStudio version:", v$version)
  }, silent = TRUE)
}
```

2 How Base R Differs from RStudio

- Base R
 - The language + interpreter/engine
 - Comes with a console and basic GUI (varies by OS)
 - You can run scripts and commands via the R console or terminal
- RStudio IDE (by Posit)
 - A graphical environment wrapping R
 - Offers script editor, plotting viewer, environment browser, package manager, project management, and integrated help

- Makes development, reproducibility, and visualization easier, but does not replace R itself

Example: Base R functionality (works the same in RStudio since RStudio calls R under the hood)

```
# Base R calculations
x <- c(1, 2, 3, 4, 5)
mean(x)
```

```
[1] 3
```

```
sd(x)
```

```
[1] 1.581139
```

```
sum(x^2)
```

```
[1] 55
```

3 Introduction to the RStudio Environment (The 4 Panes)

- Source (top-left, by default)
 - Your editor for .R scripts, .Rmd, .qmd files
 - Run code lines or chunks into the Console
- Console (bottom-left)
 - Where R commands execute
 - Shows outputs, errors, warnings
- Environment/History (top-right)
 - Environment: objects currently in memory
 - History: previously run commands
- Files/Plots/Packages/Help/Viewer (bottom-right)
 - Files: browse project files
 - Plots: view figures
 - Packages: installed packages and load/unload controls
 - Help: documentation for functions and packages
 - Viewer: renders HTML content (e.g., Quarto docs)

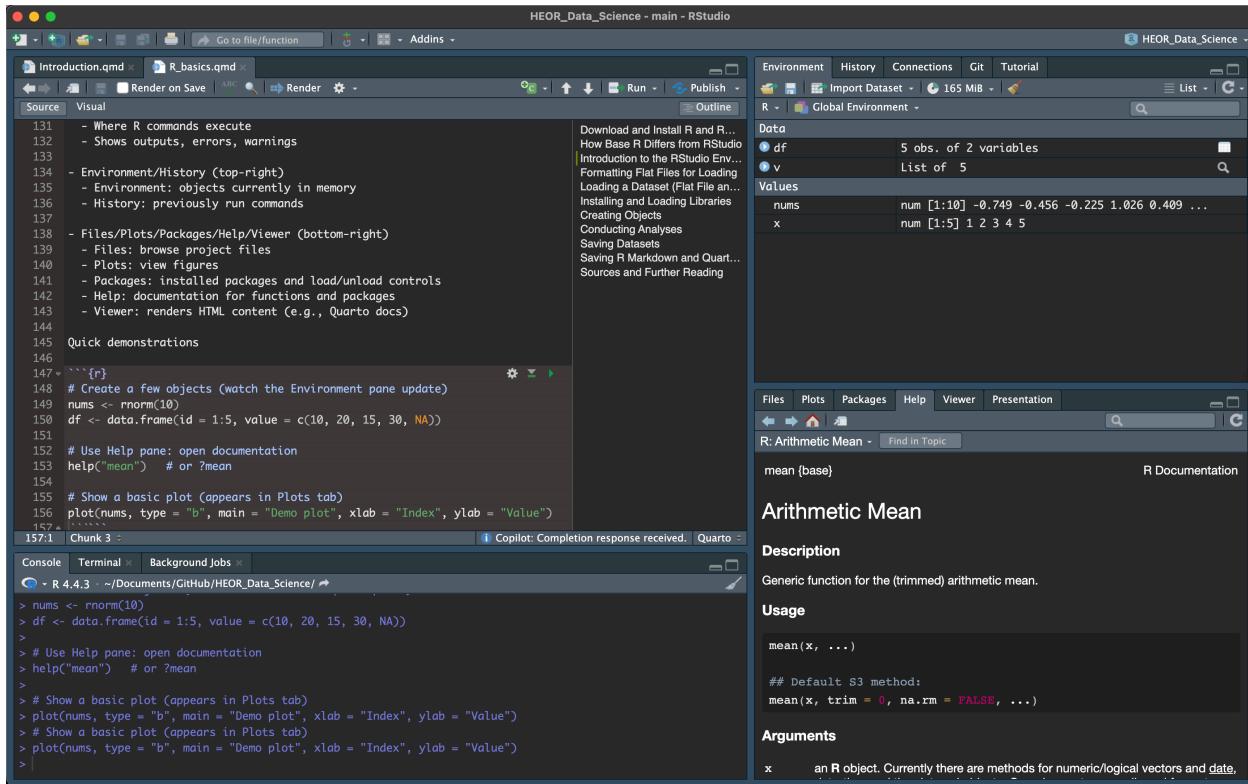


Figure 1: RStudio window

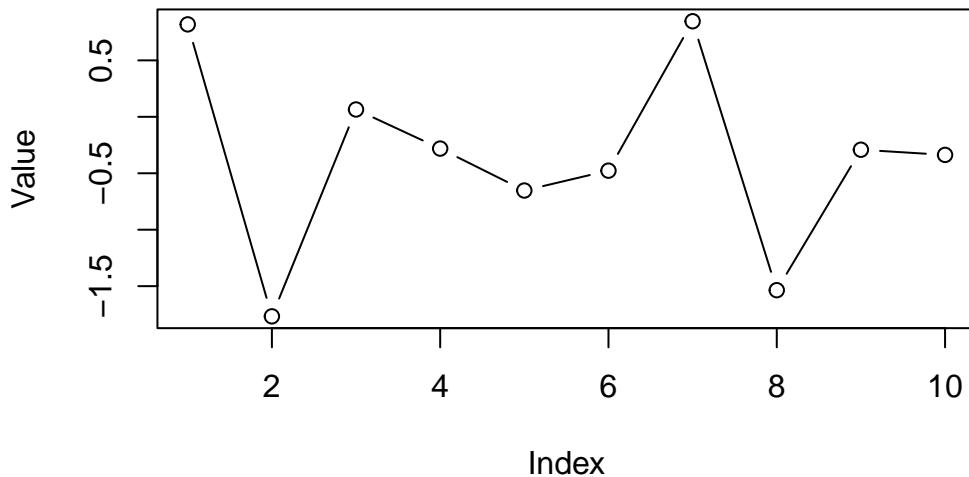
Quick demonstrations

```
# Create a few objects (watch the Environment pane update)
nums <- rnorm(10)
df <- data.frame(id = 1:5, value = c(10, 20, 15, 30, NA))

# Use Help pane: open documentation
help("mean") # or ?mean

# Show a basic plot (appears in Plots tab)
plot(nums, type = "b", main = "Demo plot", xlab = "Index", ylab = "Value")
```

Demo plot



4 Formatting Flat Files for Loading

Good practices for CSV/TSV flat files

- Use a header row with short, clear, alphanumeric column names (avoid spaces; use underscores if needed)
- Use UTF-8 encoding
- Use a consistent delimiter (comma for CSV, tab for TSV)
- Represent missing values consistently (e.g., empty cell or NA; avoid mixed values like “-”, “N/A”, “null”)
- Use ISO 8601 for dates (YYYY-MM-DD) and include time zones if timestamps are present
- Avoid embedded line breaks in cells; if present, ensure proper quoting
- Keep one “tidy” table per file: each row is one observation, each column is one variable

Create and save a well-formatted CSV

```
# Example tidy dataset
tidy_example <- data.frame(
  subject_id = 1:6,
  group = c("control", "control", "control", "treatment", "treatment", "treatment"),
  age_years = c(34, 45, 51, 29, 40, NA),
  visit_date = as.Date(c("2025-01-10", "2025-01-12", "2025-01-13", "2025-01-11", "2025-01-12",
  score = c(87, 90, 85, 92, 88, 91)
)

# Create a data folder, then save CSV
dir.create("data", showWarnings = FALSE)
```

```
csv_path <- file.path("data", "tidy_example.csv")
write.csv(tidy_example, csv_path, row.names = FALSE, na = "")
csv_path
```

```
[1] "data/tidy_example.csv"
```

5 Loading a Dataset (Flat File and Other Resources)

Load the CSV using base R

```
loaded_base <- read.csv(csv_path, stringsAsFactors = FALSE)
str(loaded_base)
```

```
'data.frame': 6 obs. of 5 variables:
 $ subject_id: int 1 2 3 4 5 6
 $ group      : chr "control" "control" "control" "treatment" ...
 $ age_years  : int 34 45 51 29 40 NA
 $ visit_date: chr "2025-01-10" "2025-01-12" "2025-01-13" "2025-01-11" ...
 $ score      : int 87 90 85 92 88 91
```

```
head(loaded_base)
```

	subject_id	group	age_years	visit_date	score
1	1	control	34	2025-01-10	87
2	2	control	45	2025-01-12	90
3	3	control	51	2025-01-13	85
4	4	treatment	29	2025-01-11	92
5	5	treatment	40	2025-01-12	88
6	6	treatment	NA	2025-01-14	91

Load the CSV using readr (tidyverse) for better performance and type control

```
# Install readr if needed (run once; eval is FALSE so it won't execute automatically)
# install.packages("readr")
```

```
# If readr is available, demonstrate its use safely
if (requireNamespace("readr", quietly = TRUE)) {
  loaded_readr <- readr::read_csv(csv_path, show_col_types = FALSE)
  print(loaded_readr)
}
```

```
# A tibble: 6 x 5
  subject_id group    age_years visit_date score
  <dbl> <chr>      <dbl> <date>     <dbl>
1       1 control      34 2025-01-10    87
2       2 control      45 2025-01-12    90
3       3 control      51 2025-01-13    85
4       4 treatment    29 2025-01-11    92
5       5 treatment    40 2025-01-12    88
6       6 treatment    NA 2025-01-14    91
```

Handling column types and missing values explicitly with readr

```
if (requireNamespace("readr", quietly = TRUE)) {
  loaded_typed <- readr::read_csv(
    csv_path,
    col_types = readr::cols(
      subject_id = readr::col_integer(),
      group = readr::col_factor(levels = c("control", "treatment")),
      age_years = readr::col_double(),
      visit_date = readr::col_date(),
      score = readr::col_double()
    ),
    show_col_types = FALSE
  )
  str(loaded_typed)
}
```

```
spc_tbl_ [6 x 5] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
$ subject_id: int [1:6] 1 2 3 4 5 6
$ group      : Factor w/ 2 levels "control","treatment": 1 1 1 2 2 2
$ age_years   : num [1:6] 34 45 51 29 40 NA
$ visit_date: Date[1:6], format: "2025-01-10" "2025-01-12" ...
$ score      : num [1:6] 87 90 85 92 88 91
- attr(*, "spec")=
.. cols(
..   subject_id = col_integer(),
..   group = col_factor(levels = c("control", "treatment"), ordered = FALSE, include_na = FALSE),
..   age_years = col_double(),
..   visit_date = col_date(format = ""),
..   score = col_double()
.. )
- attr(*, "problems")=<externalptr>
```

Reading Excel files

```
# install.packages("readxl") # run once
if (requireNamespace("readxl", quietly = TRUE)) {
  # Example: readxl::read_excel("data/example.xlsx", sheet = 1)
  # (We won't read here unless a file exists)
}
```

NULL

Other dataset resources

- Built-in datasets: datasets::mtcars, iris, airquality
- Public datasets:
 - palmerpenguins: <https://allisonhorst.github.io/palmerpenguins/>
 - TidyTuesday datasets: <https://github.com/rfordatascience/tidytuesday>
 - UCI Machine Learning Repository: <https://archive.ics.uci.edu/>
 - Kaggle: <https://www.kaggle.com/datasets>
 - data.gov (US): <https://data.gov/>
 - World Bank Data: <https://data.worldbank.org/>

6 Installing and Loading Libraries

Install packages (run once; do not run inside production pipelines without a lockfile)

```
# Example install (set eval: false to avoid automatic install)
# install.packages(c("tidyverse", "readr", "dplyr", "ggplot2", "readxl", "data.table"))
```

Load packages

```
# Load if available; fall back gracefully if not
loaded_pkgs <- c()
for (pkg in c("dplyr", "ggplot2")) {
  if (requireNamespace(pkg, quietly = TRUE)) {
    library(pkg, character.only = TRUE)
    loaded_pkgs <- c(loaded_pkgs, pkg)
  }
}
loaded_pkgs
```

```
[1] "dplyr"    "ggplot2"
```

Notes

- Use `install.packages("packagename")` once per machine or project
- Use `library(packagename)` in each session/script where needed
- Consider project environments for reproducibility (e.g., `renv`)

7 Creating Objects

Basic objects

```
# Numeric and character vectors
a <- c(10, 20, 30)
b <- c("alpha", "beta", "gamma")

# Factors
grp <- factor(c("control", "treatment", "control"), levels = c("control", "treatment"))

# Matrices
m <- matrix(1:9, nrow = 3)

# Lists (heterogeneous containers)
my_list <- list(nums = a, labels = b, flag = TRUE)

# Data frames (tabular)
df2 <- data.frame(id = 1:3, group = grp, score = c(88, 92, 85))
str(df2)
```

```
'data.frame': 3 obs. of 3 variables:
$ id   : int 1 2 3
$ group: Factor w/ 2 levels "control","treatment": 1 2 1
$ score: num 88 92 85
```

```
# Functions
add_two <- function(x) x + 2
add_two(5)
```

```
[1] 7
```

8 Conducting Analyses

Descriptive statistics (base R)

```
x <- rnorm(100, mean = 50, sd = 10)
summary(x)
```

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
29.43	41.54	48.35	49.08	56.68	74.30

```
mean(x); median(x); sd(x); quantile(x, probs = c(0.25, 0.5, 0.75))
```

```
[1] 49.08299
```

```
[1] 48.35002
```

```
[1] 9.933863
```

```
25%      50%      75%
41.53819 48.35002 56.67534
```

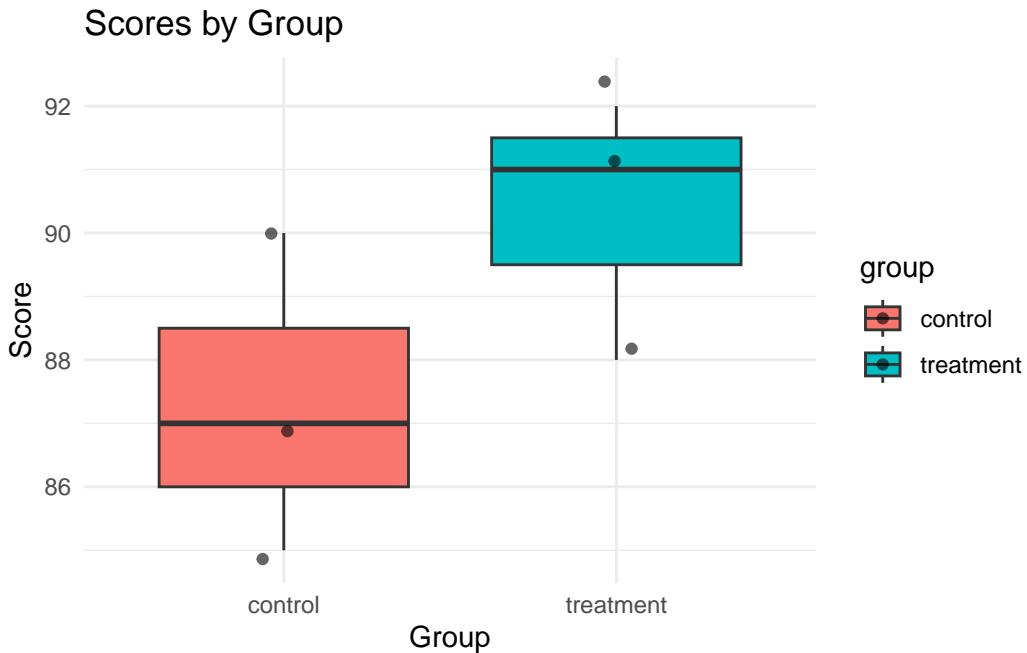
Group-wise summaries (dplyr, if available)

```
if (requireNamespace("dplyr", quietly = TRUE)) {
  library(dplyr)
  loaded_base %>%
    group_by(group) %>%
    summarise(
      n = n(),
      mean_score = mean(score, na.rm = TRUE),
      mean_age = mean(age_years, na.rm = TRUE)
    )
}
```

```
# A tibble: 2 x 4
  group      n  mean_score  mean_age
  <chr>    <int>     <dbl>     <dbl>
1 control      3      87.3      43.3
2 treatment    3      90.3      34.5
```

Visualization (ggplot2, if available)

```
if (requireNamespace("ggplot2", quietly = TRUE)) {
  library(ggplot2)
  ggplot(loaded_base, aes(x = group, y = score, fill = group)) +
    geom_boxplot() +
    geom_jitter(width = 0.1, alpha = 0.6) +
    labs(title = "Scores by Group", x = "Group", y = "Score") +
    theme_minimal()
}
```



Linear regression

```
# Fit a simple model on built-in mtcars dataset
fit <- lm(mpg ~ wt + cyl, data = mtcars)
summary(fit)
```

Call:
`lm(formula = mpg ~ wt + cyl, data = mtcars)`

Residuals:

Min	1Q	Median	3Q	Max
-4.2893	-1.5512	-0.4684	1.5743	6.1004

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	39.6863	1.7150	23.141	< 2e-16 ***
wt	-3.1910	0.7569	-4.216	0.000222 ***
cyl	-1.5078	0.4147	-3.636	0.001064 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.568 on 29 degrees of freedom
Multiple R-squared: 0.8302, Adjusted R-squared: 0.8185
F-statistic: 70.91 on 2 and 29 DF, p-value: 6.809e-12

T-test (group comparison)

```
# Compare mpg for automatic vs manual transmissions
t.test(mpg ~ am, data = mtcars)
```

Welch Two Sample t-test

```
data: mpg by am
t = -3.7671, df = 18.332, p-value = 0.001374
alternative hypothesis: true difference in means between group 0 and group 1 is not equal to 0
95 percent confidence interval:
-11.280194 -3.209684
sample estimates:
mean in group 0 mean in group 1
17.14737      24.39231
```

Contingency table and chi-squared test

```
tbl <- table(mtcars$cyl, mtcars$gear)
tbl
```

	3	4	5
4	1	8	2
6	2	4	1
8	12	0	2

```
chisq.test(tbl)
```

Pearson's Chi-squared test

```
data: tbl
X-squared = 18.036, df = 4, p-value = 0.001214
```

9 Saving Datasets

Save to CSV (portable)

```
# Save mtcars as CSV
out_csv <- file.path("data", "mtcars_export.csv")
dir.create("data", showWarnings = FALSE)
write.csv(mtcars, out_csv, row.names = FALSE)
out_csv
```

```
[1] "data/mtcars_export.csv"
```

Save to RDS (preserves R types precisely, single object)

```
out_rds <- file.path("data", "mtcars.rds")
saveRDS(mtcars, out_rds)
# Load back
mtcars_loaded <- readRDS(out_rds)
identical(mtcars, mtcars_loaded)
```

```
[1] TRUE
```

Save multiple objects to .RData (workspace-like)

```
out_rdata <- file.path("data", "analysis_objects.RData")
obj1 <- 123
obj2 <- data.frame(x = 1:3, y = c("a", "b", "c"))
save(obj1, obj2, file = out_rdata)
# Load back
rm(obj1, obj2)
load(out_rdata)
obj1; obj2
```

```
[1] 123
```

```
  x y
1 1 a
2 2 b
3 3 c
```

10 Saving R Markdown and Quarto Files

Saving files

- In RStudio:
 - File -> New File -> Quarto Document
 - File -> Save (choose .qmd extension)
 - For R Markdown: File -> New File -> R Markdown, then Save as .Rmd

Rendering (turn .qmd or .Rmd into HTML/PDF/Word)

```
# Quarto render (requires Quarto installed)
# install.packages("quarto") is not needed; Quarto is a separate tool you install from https://quarto.org/
# From R you can call:
if (requireNamespace("quarto", quietly = TRUE)) {
  # quarto::quarto_render("your_document.qmd")
}
```

NULL

```
# R Markdown render (requires rmarkdown package)
# install.packages("rmarkdown") # run once
if (requireNamespace("rmarkdown", quietly = TRUE)) {
  # rmarkdown::render("your_document.Rmd", output_format = "html_document")
}
```

NULL

Command-line rendering (outside R)

- Quarto:
 - Install Quarto: <https://quarto.org/docs/get-started/>
 - In a terminal: quarto render your_document.qmd
- R Markdown (legacy):
 - In RStudio: click “Knit”
 - Or in R: rmarkdown::render("your_document.Rmd")

Export formats

- HTML (default), PDF (requires LaTeX), Word (docx)
- Choose output format in the YAML header or via render arguments

11 Sources and Further Reading

- R (CRAN) downloads: <https://cran.r-project.org/>
- RStudio Desktop by Posit: <https://posit.co/download/rstudio-desktop/>
- Quarto documentation: <https://quarto.org/docs/>
- R for Data Science (2e): <https://r4ds.hadley.nz/>
- Advanced R (3e): <https://adv-r.hadley.nz/>
- Tidyverse packages: <https://www.tidyverse.org/>
- readr (fast reading/writing): <https://readr.tidyverse.org/>
- dplyr (data manipulation): <https://dplyr.tidyverse.org/>
- ggplot2 (visualization): <https://ggplot2.tidyverse.org/>
- R Markdown (legacy): <https://rmarkdown.rstudio.com/>
- Base R documentation (manuals): <https://cran.r-project.org/manuals.html>

- RStudio IDE docs: <https://docs.posit.co/ide/>
- Data import best practices (readr vignette): <https://readr.tidyverse.org/articles/readr.html>
- Palmer Penguins dataset: <https://allisonhorst.github.io/palmerpenguins/>
- TidyTuesday: <https://github.com/rfordatascience/tidytuesday>
- UCI ML Repository: <https://archive.ics.uci.edu/>
- Kaggle datasets: <https://www.kaggle.com/datasets>
- data.gov: <https://data.gov/>